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Type test report no. VR/R/VM/M 3E 001e

**Short circuit current test of
tap selector and change-over selector**

Product Approval
TETP/Wag
16.07.2020

Type test for types: Tap selectors of sizes “RC”, “RD” and “RDE” without change-over selector, with reversing change-over selector or with coarse change-over selector, designed with 1, 2 or 3 current paths (connected in parallel) for use in combination with single phase, 2 phase or 3 phase diverter switches type VACUTAP® VR, VACUTAP® VM, OILTAP® R or OILTAP® M.

Test specification: IEC 60214-1:2014, sub-clause 5.2.4: “Short-circuit current test”.

Test samples: 1: VRF III 1300 Y – 72,5/RDE – 10 19 3G, S/N: 1525722.
2: R I 3003 – 72.5/RDE – 10 19 3W, S/N: 1525721.

Manufacturer: Maschinenfabrik Reinhausen GmbH, Regensburg, Germany.

Date of test: November 2014 to December 2014.

Place of test: Maschinenfabrik Reinhausen GmbH, Regensburg, Germany.

Tests performed: The tests were performed on one phase, on all contacts of different design carrying current continuously in service.
According to IEC 60214-1:2014 three applications were carried out with an initial peak current of 2.5 times the r.m.s. value of the rated short-circuit test current. The contacts were not moved between these applications.

		Requirement IEC 60214-1	Rated values	Tested values
Design variant with 1 single current path (test sample 1)	Initial peak current	32.5 kA	40.0 kA	41.01 kA
	Short-circuit current (r.m.s)	13.0 kA	16 kA	16.68 kA
	Test duration	2 s	3 s	2.94 s
Design variant with 3 parallel current paths (test sample 2)	Initial peak current	75.0 kA	75.0 kA	76.0 kA
	Short-circuit current (r.m.s)	30.0 kA	30.0 kA	30.9 kA
	Test duration	2 s	3 s	2.91 s

Test results: The requirements of IEC 60214-1:2014 were met, i.e.:
- At the conclusion of the test, the contacts were not damaged.
- The measurement of the initial driving torque before and after the test showed suitability for service.
- Other current-carrying parts did not show any signs of permanent mechanical distortion, which could influence the normal operation of the tap selector.

This report contains 9 pages.

i. V. Dr. Thomas Strof
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Maschinenfabrik Reinhausen GmbH
- PRODUCT APPROVAL -

1. Test specification

The type tests were performed in accordance with IEC 60214-1:2014 “Tap-changers - Part 1: Performance requirements and test methods”, sub-clause 5.2.4: “Short-circuit current test”.

2. Data of test samples

Test sample no.:	**1**
On-load tap changer:	VRF III 1300 Y – 72,5/RDE – 10 19 3G
Serial no. / IBASE:	1525722 / 468950866
Year of manufacture:	2014
Part of test:	Tap selector
Test sample no.:	**2**
On-load tap changer:	R I 3003 – 72.5/RDE – 10 19 3W
Serial no. / IBASE:	1525721 / 477030595
Year of manufacture:	2014
Part of test:	Tap selector

3. Scope of application

Tap selectors of sizes “RC”, “RD” and “RDE” are designed on the principle of a modular system, allowing a wide range of different variations, e.g. number of contacts, number of contact planes, number of parallel current paths (per phase) and type of change-over selector. Tap selectors of sizes “RC”, “RD” and “RDE” are designed for use in combination with diverter switches VACUTAP® VR, VACUTAP® VM, OILTAP® R or OILTAP® M.

Depending on the type of diverter switch the tap selector is combined with, tap selectors of sizes “RC”, “RD” and “RDE” are available in following basic designs:

- Maximum rated through-current 1300 A with 1 single current path (per phase).
- Maximum rated through-current 2000 A with 2 current paths connected in parallel.
- Maximum rated through-current 3000 A with 3 current paths connected in parallel.
- Maximum rated through-current 2600 A with 2 current paths for applications with enforced current splitting.

The design of contacts that carry current continuously is identical for all tap selectors of sizes “RC”, “RD” and “RDE” with reversing change-over selector, coarse change-over selector or without change-over selector.

Tap selectors of size "RDE" with 10 contacts have the maximum overall length and the minimum number of contact bars. Furthermore, types with reversing change-over selector have the longest copper connection lines.

Both the selected test samples were of size "RDE" and equipped with 10 contacts. Test sample 2 was in single phase design with three current paths connected in parallel, maximum rated through-current 3000 A and with reversing change-over selector. Concerning the occurring short-circuit stress, this variant had the most critical design. Test sample 1 was in three phase design with a single current path per phase and maximum rated through-current 1300 A (per phase). This test sample was representative for the highest maximum rated through-current per current path. The type of change-over selector was not relevant in this case.

Single phase tap selectors with 2 parallel current paths and maximum rated through-current 2000 A resp. 2600A (for applications with enforced current splitting) were not tested explicit because the rated initial peak current and rated short-time current (r.m.s) per current path are significantly lower than of test sample 1. Additionally with test sample 2 the absolute highest rated initial peak current and rated short-time current (r.m.s) for this selector design were tested, which are significantly higher than for designs with 2 parallel current paths. Thus, tap selectors of sizes “RC”, “RD” and “RDE” with 2 parallel current paths (with or without enforced current splitting) are covered by the performed tests.

The short-circuit current capability does not depend on the insulation levels, the number of contacts and the type of diverter switch (VACUTAP® VR, VACUTAP® VM, OILTAP® R or OILTAP® M) the tap selector is combined with.

Therefore this type test report is valid for all tap selectors with following characteristics:

- Tap selector size: “RC”, “RD” or “RDE”
- Change-over selector: without, reversing or coarse change-over selector
- Combined diverter switch: VACUTAP® VR, VACUTAP® VM, OILTAP® R or OILTAP® M
- Maximum rated through-current: 1300 A, 2000 A, 2600 A and 3000 A
- Number of phases: 1, 2 or 3
- Parallel current paths (per phase): 1, 2 or 3

4. Test arrangement

Schematic test circuits:	See figure 1a (test sample 1) and figure 1b (test sample 2).
Position and connection:	See figure 1a (test sample 1) and figure 1b (test sample 2).
Surrounding medium:	Transformer oil according to the requirements of IEC 60296.
Adjustment and measurement:	Short-circuit current adjusted by air-core reactor and measured by
	Rogowski transformer, see figure 1a and 1b.
	The initial driving torque before and after the short-circuit current tests was measured by torque sensor and transient recorder.
Testing transformer:	4000 kVA, 20 kV, open-circuit voltage U_0: >50 V.
Condition of the test sample:	Temperature rise of contacts test carried out before.
Servicing during the tests:	No servicing during the tests.
Recording and evaluation:	Each test was recorded and evaluated by transient recorder.

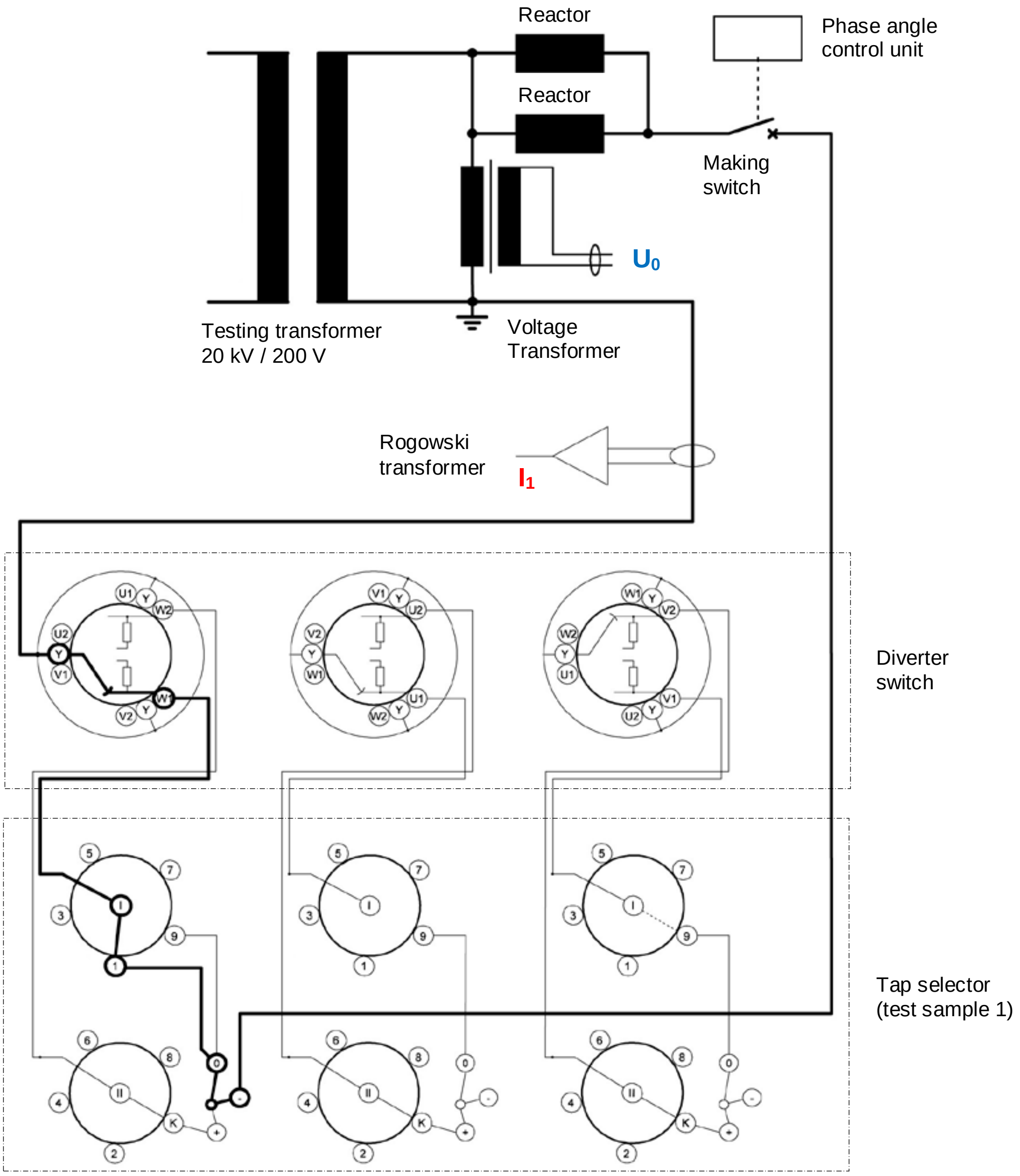


Figure 1a: Schematic test circuit and connection of the test sample (test sample 1).

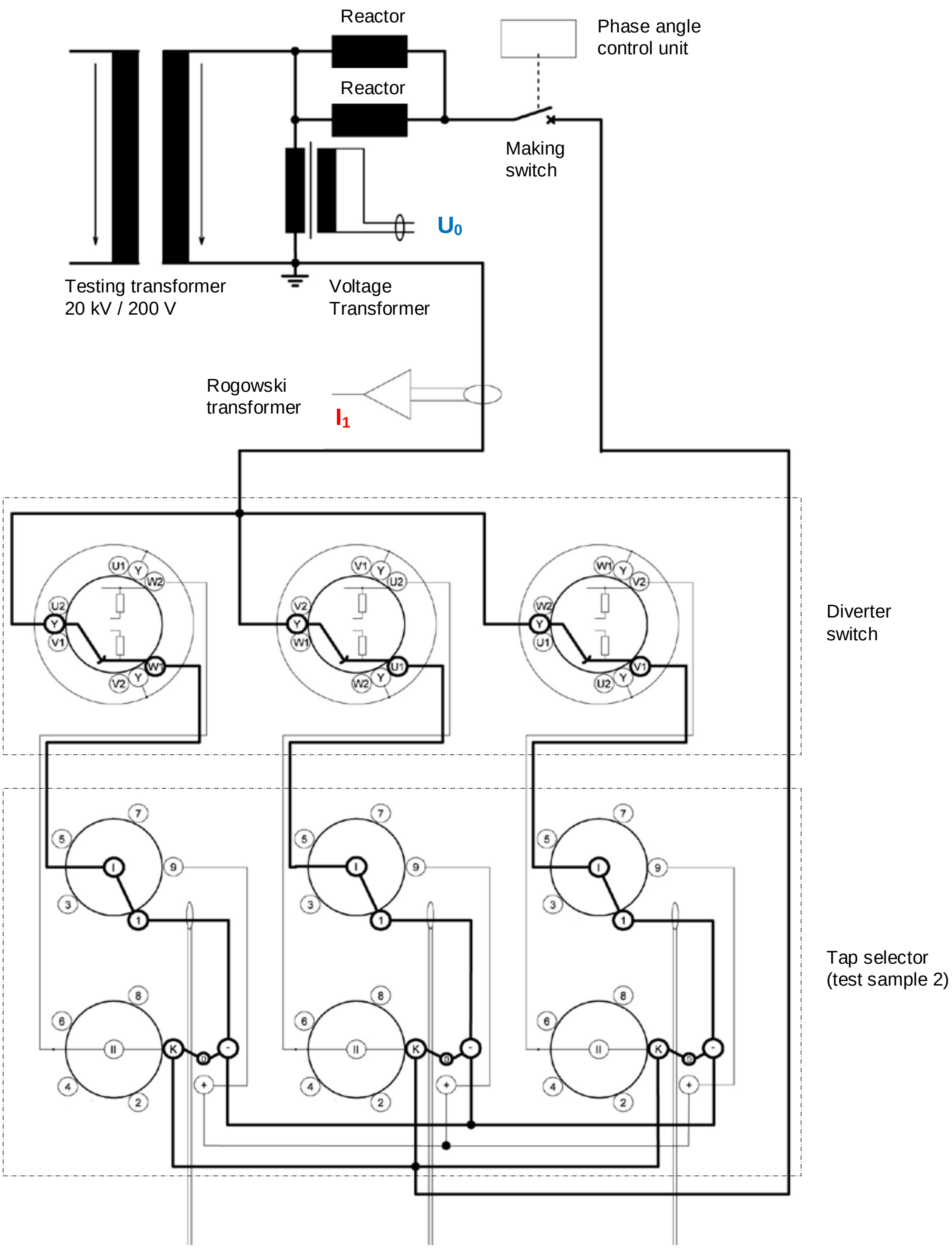


Figure 1b: Schematic test circuit and connection of the test sample (test sample 2).

5. Required short-circuit strength acc. to IEC 60214-1:2014

Test sample no.:	1	2
Maximum rated through-current:	1300 A	3000 A
Number of tests:	3	3
Initial peak current:	32.5 kA	75.0 kA
Short-circuit current (r.m.s):	13.0 kA	30.0 kA
Test duration:	2 s	2 s

6. Tests performed

The test was performed on two test samples. Test sample 1 was in 3 phase design with one single current path per phase and maximum rated through-current 1300 A. Test sample 2 was in single phase design with 3 current paths connected in parallel and maximum rated through-current 3000 A.

Table 1a shows the tested short-circuit values of test sample 1 and table 1b shows the tested short-circuit values of test sample 2. Figures 2…7 show recordings of the performed applications.

Application no.	Initial peak current I_{1p}	Short-circuit current I_1 (r.m.s)	Short-circuit duration t	Equivalent short-time current (r.m.s)
1	41.06 kA	16.69 kA	2.93 s	16.5 kA – 3 s
2	41.19 kA	16.68 kA	2.95 s	16.5 kA – 3 s
3	40.92 kA	16.67 kA	2.93 s	16.5 kA – 3 s
Mean values	41.01 kA	16.68 kA	2.94 s	16.5 kA – 3 s

Table 1a: Tested short-circuit current values of test sample 1 (Design variant with one single current path).

Application no.	Initial peak current I_{1p}	Short-circuit current I_1 (r.m.s)	Short-circuit duration t	Equivalent short-time current (r.m.s)
1	75.85 kA	30.91 kA	2.91 s	30.4 kA – 3 s
2	75.97 kA	30.85 kA	2.91 s	30.4 kA – 3 s
3	76.15 kA	30.89 kA	2.91 s	30.4 kA – 3 s
Mean values	76.0 kA	30.9 kA	2.91 s	30.4 kA – 3 s

Table 1b: Tested short-circuit current values of test sample 2 (Design variant with 3 parallel current paths).

Table 2 shows the measured initial driving torque of both test samples before and after the test.

Timing of measurement	Initial driving torque test sample 1	Initial driving torque test sample 2
Before the test	106.3 Nm	140.3 Nm
After the test	108.0 Nm	142.6 Nm

Table 2: Measurement of the initial driving torque.

Table 3 shows the tap selector variants covered by this test.

Maximum rated through current	Number of (parallel) current paths	Enforced current splitting	Rated initial peak current	Rated short-time current (r.m.s)
1300 A	1	no	40.0 kA	16.0 kA – 3 s
2000 A	2	no	60.0 kA	24.0 kA – 3 s
2600 A	2	yes	65.0 kA	26.0 kA – 3 s
3000 A	3	no	75.0 kA	30.0 kA – 3 s

Table 3: Tap selector variants covered by this type test.

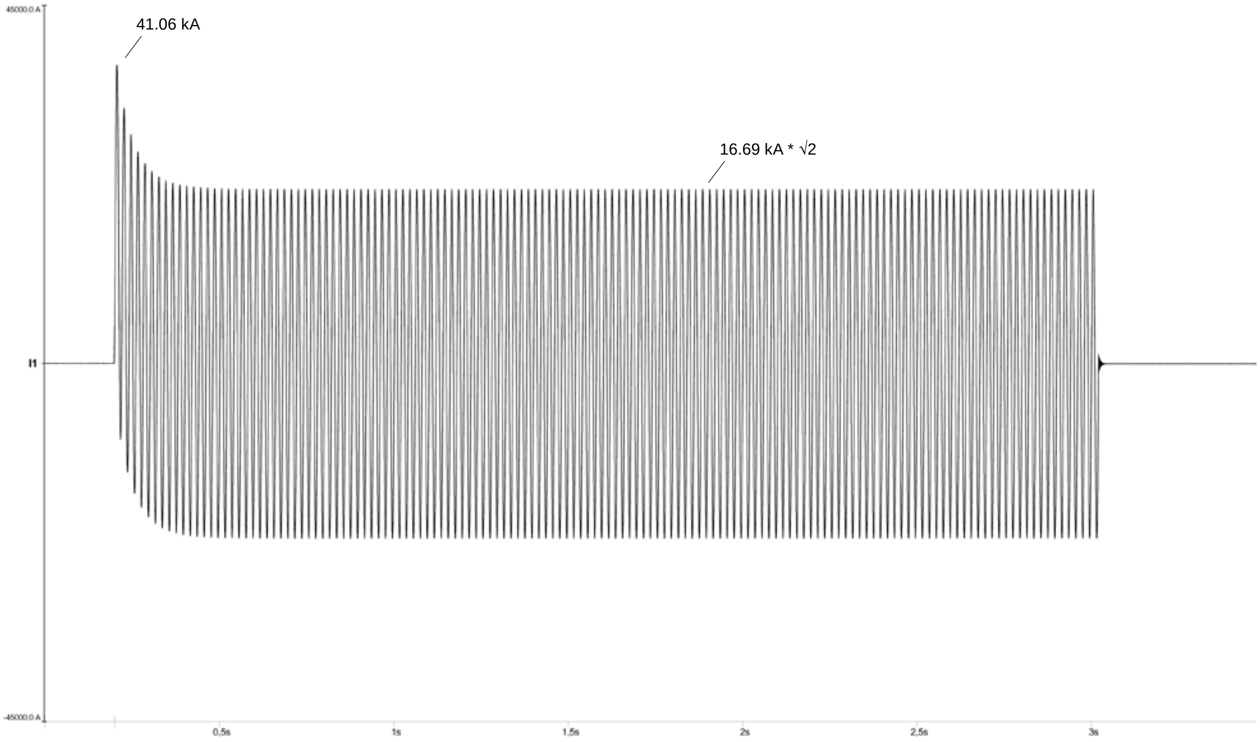


Figure 2: Test sample 1 (single current path) - Recording of application no. 1.

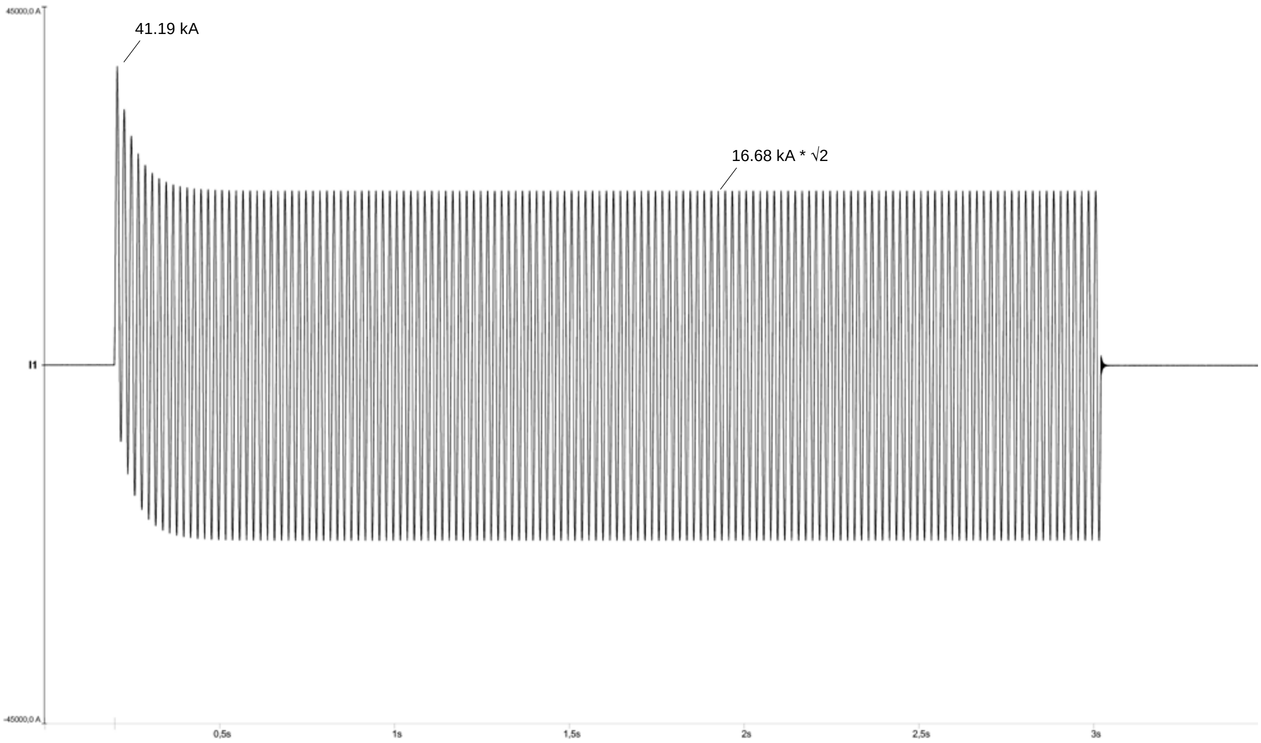
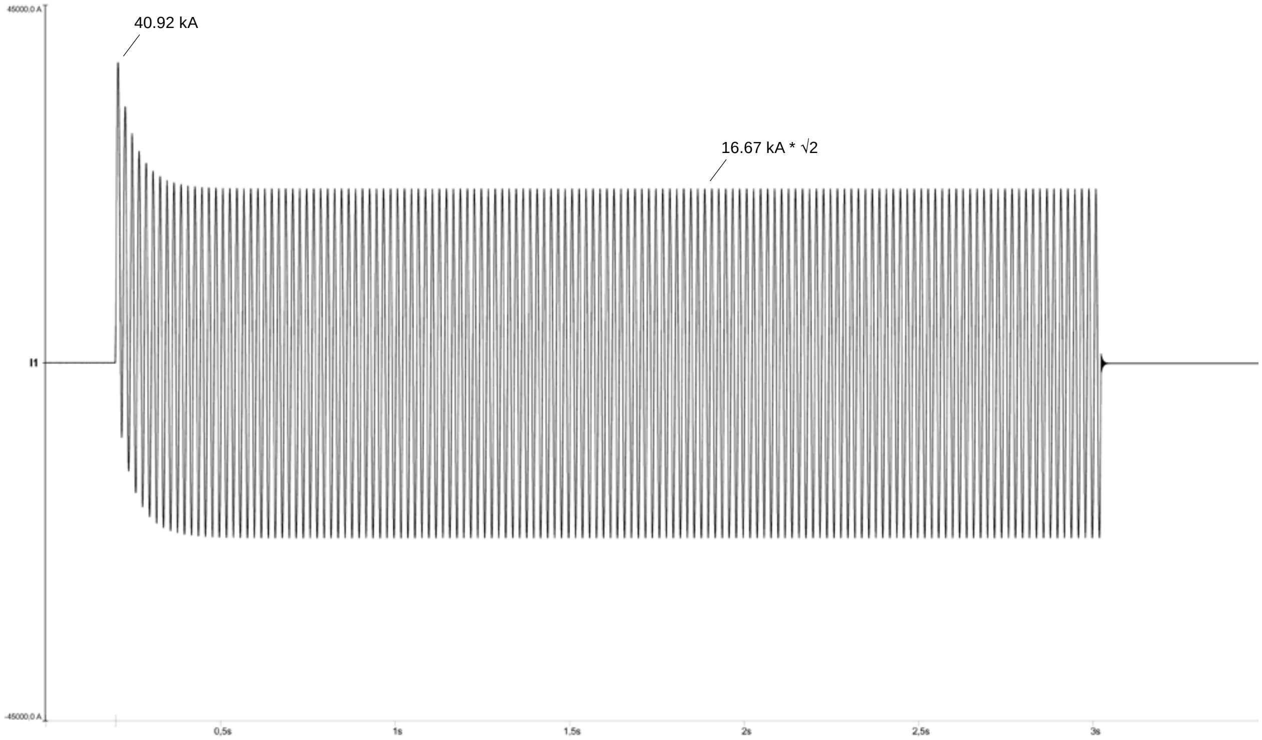
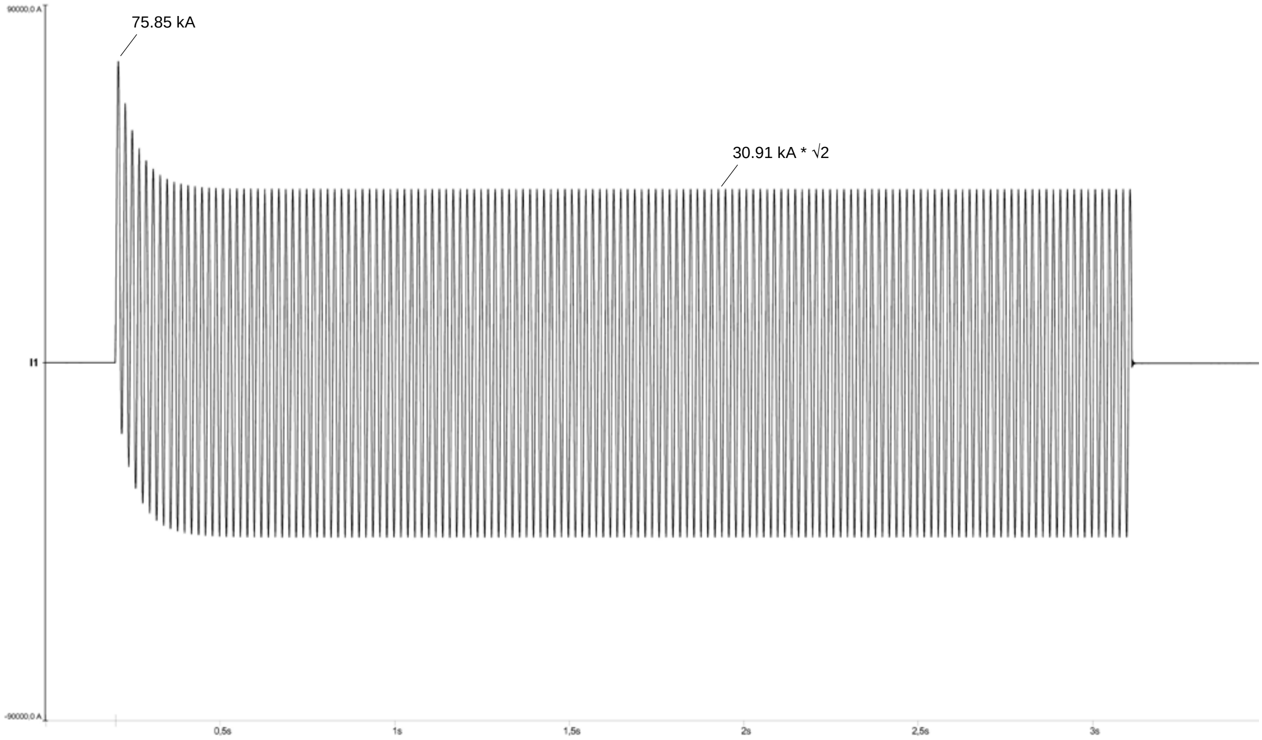


Figure 3: Test sample 1 (single current path) - Recording of application no. 2.



<u>Figure 4:</u> Test sample 1 (single current path) - Recording of application no. 3.



<u>Figure 5:</u> Test sample 2 (3 parallel current paths) - Recording of application no. 1.

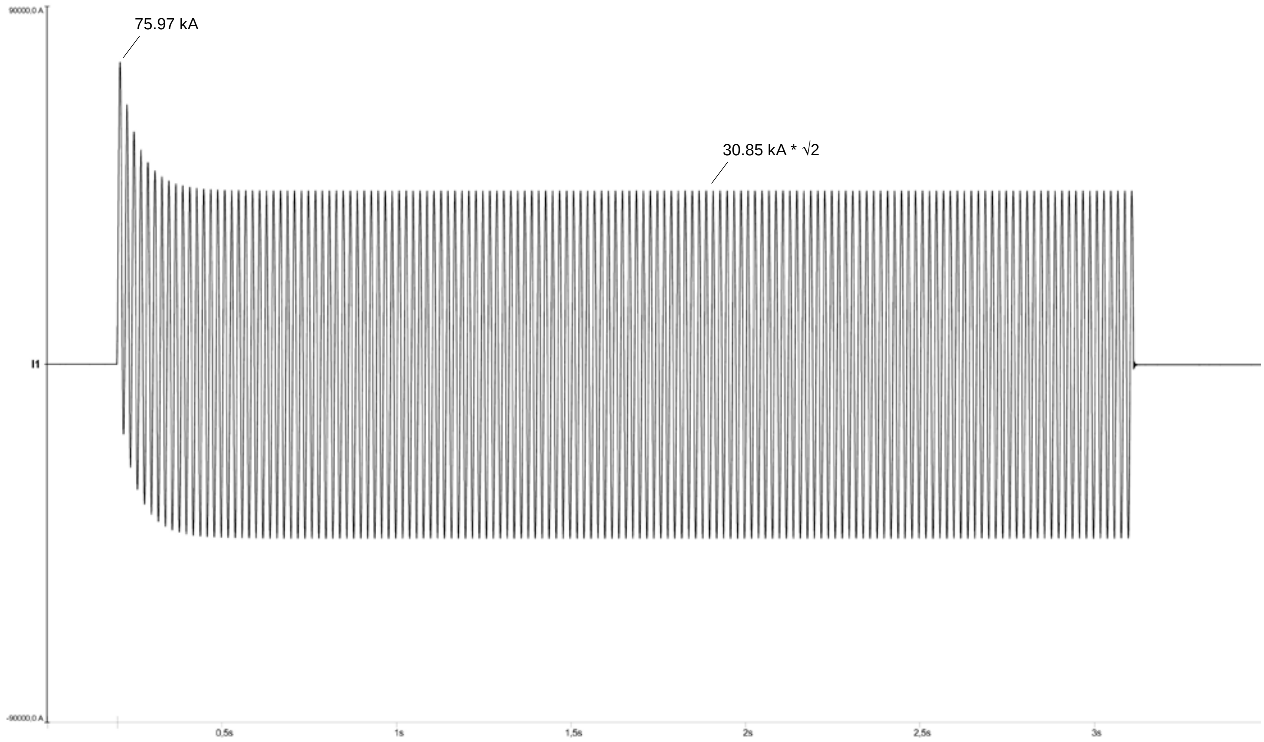


Figure 2: Test sample 2 (3 parallel current paths) - Recording of application no. 2.

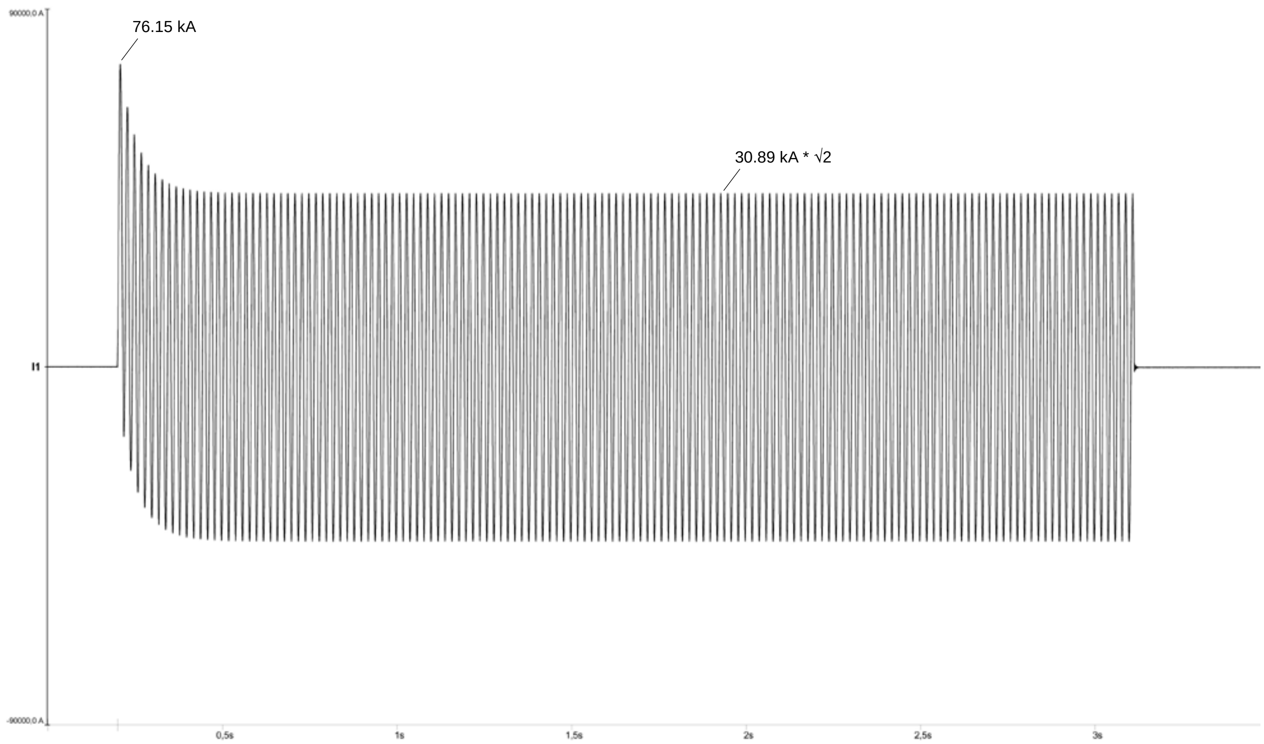


Figure 3: Test sample 2 (3 parallel current paths) - Recording of application no. 3.

7. Test results

The requirements of IEC 60214-1:2014 “Tap-changers - Part 1: Performance requirements and test methods”, sub-clause 5.2.4 “Short-circuit current test” were met.

The contacts were not damaged, therefore the capability of carrying the maximum rated through-current was not reduced.

The measurement of the initial driving torque before and after the test showed suitability for service.

Other current-carrying parts did not show any signs of permanent mechanical distortion, which could influence the normal operation of the tap selector.